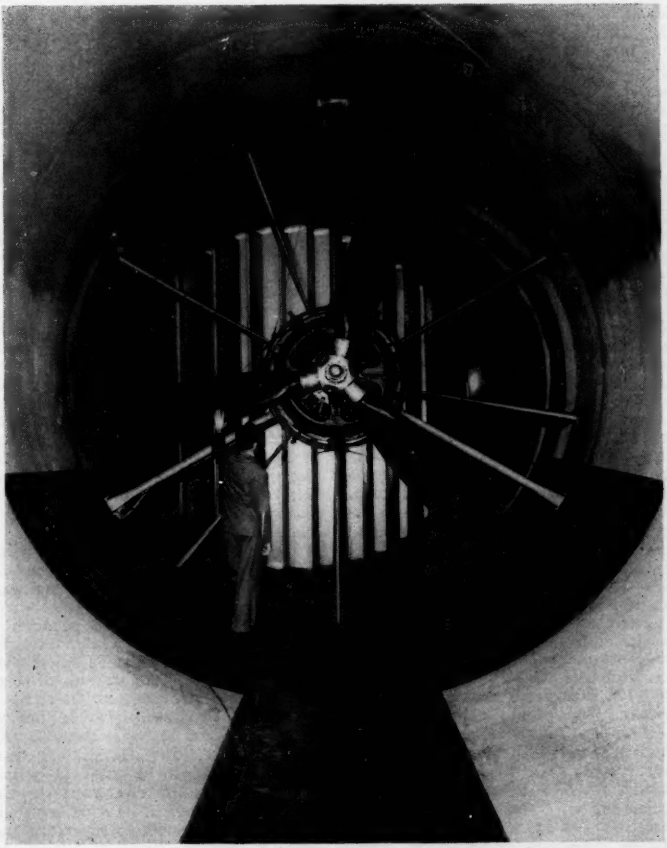
STATE ENGINEERING EXPERIMENT STATION

The Research Engineer

GEORGIA INSTITUTE OF TECHNOLOGY

NOVEMBER ATLANTA, GEORGIA 1948



The Research Engineer

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AERONAUTICAL ENGINEERING

Today, even the youngest schoolboy knows that airplanes are of prime importance to modern transportation and — unfortunately — to modern warfare. All who have heard of the atomic bomb are aware that both of those missiles used against Japan were dropped from the air, just as present-day visitors to Germany know full well whence came the bombs which wreaked such havoc.

Back of the airplanes which fill the skies in peace and war are the aeronautical engineers who design them, experiment with trial models, and see to their proper construction. In turn, back of these aeronautical engineers are the several aeronautical engineering schools of this country, whose efforts in education and research are responsible for much of the aeronautical progress in recent years.

The Georgia Tech School of Aeronautical Engineering — the Daniel Guggenheim School of Aeronautics — was established in 1930 through a gift of $300,000 from the Daniel Guggenheim Fund for the Promotion of Aeronautics. Now housed in two buildings, and with additional laboratory space at the Marietta Air Force Base, this school possesses considerable equipment of value in research and education — a nine-foot wind tunnel, a two-and-one-half-foot wind tunnel, an instrument laboratory, a machine and woodworking shop, an aircraft structural testing laboratory, a fatigue testing machine, a special universal testing machine, an extensive technical library on aeronautical subjects, etc.

This school has long engaged in graduate research, in addition to industrial research performed by members of its staff for various aircraft companies, Governmental agencies, and the armed forces. In this issue of THE RESEARCH ENGINEER, for example, are digests of graduate theses submitted in 1947–48 and a description of the new balance system for the Georgia Tech Nine-Foot Wind Tunnel, typical of some of the extensive research and research equipment of this school.

There are those who fervently wish that the airplane had never been invented and that scientists and engineers had never been able to tap the sources of nuclear energy for the production of "atomic" bombs. Only dictators delude themselves with the belief that anyone can stop the spread of true knowledge, however, and research in scientific and engineering fields goes on apace, regardless of social theorists and dictators alike. Aeronautical engineering is typical of the fields in which engineering institutions such as the Georgia Institute of Technology are able to render service in education and research.

THE NEW BALANCE SYSTEM FOR THE GEORGIA TECH NINE-FOOT WIND TUNNEL

By E. I. BRICKER *

Aeronautical research has long played an important role in the work of the Daniel Guggenheim School of Aeronautics of the Georgia Institute of Technology. Much of this research has centered around wind tunnel studies, conducted either in a search for knowledge or as a service to aircraft companies and Government agencies. The following article describes a new balance system for Georgia Tech's nine-foot wind tunnel, a system which has greatly increased the research potential of this tunnel.

In 1932, when the Georgia Tech Nine-Foot Wind Tunnel was placed in operation at the Daniel Guggenheim School of Aeronautics, the world's speed record for airplanes was 294 miles per hour, and the best transport planes cruised at about 140 miles per hour. While these speeds now seem rather insignificant when compared with those of present planes which are experimentally probing the supersonic region, and with transport aircraft such as those having a 300-miles-per-hour schedule time between New York and London, it must be remembered that progress such as this could not have been achieved without extensive research. It is equally evident that if progress is to continue, new and improved research facilities and techniques must lead the way. Existing research equipment must be continually modernized to prevent it from rapidly becoming obsolete.

In accordance with this line of thought, the latest step in the modernization of the Georgia Tech Wind Tunnel has been the installation of a new balance system at an over-all cost of approximately $50,000. This balance system was built to Georgia

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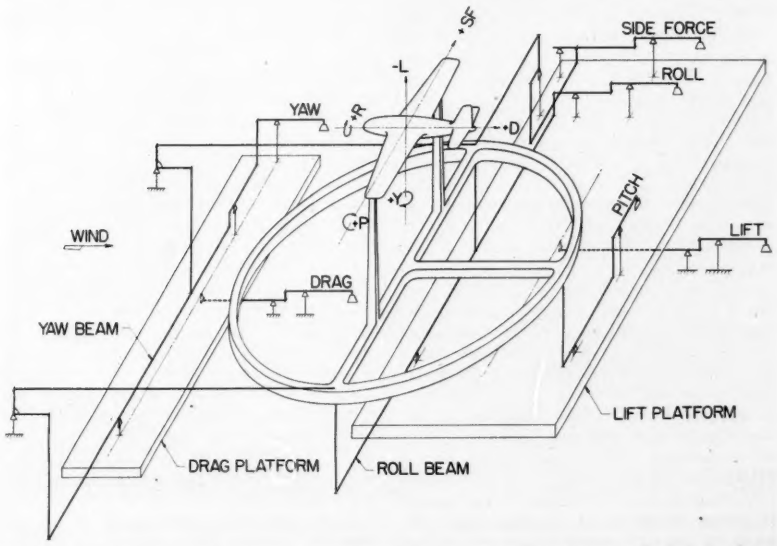

Figure 1. Schematic diagram of balance linkage system, showing how the various forces and moments are separated and measured.

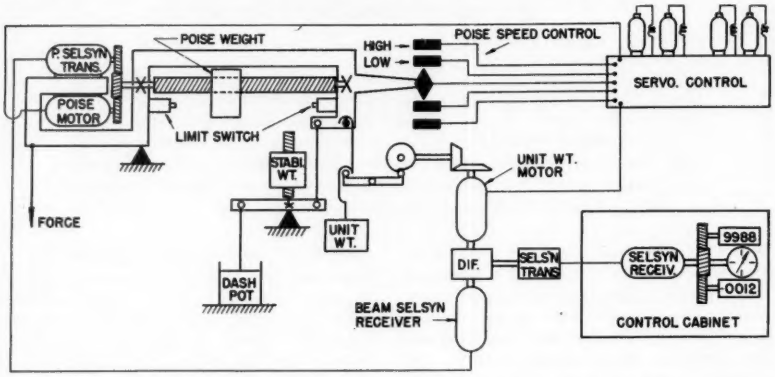

Figure 2. Schematic diagram of electronic beam balance. For simplicity, numerous interlocking switches and relays have been omitted.

Tech specifications by Taller & Cooper Manufacturing Company of Brooklyn, New York, and the installation and calibration of the system were performed by the staff of the School of Aeronautics.

DESCRIPTION OF THE NEW BALANCE

In most wind tunnel testing, the model under study is held stationary and the wind is blown over it. Particularly in the case of an airplane, the model being tested must be considered as a body in free space, hence it is essential that the forces and moments along and about three mutually perpendicular axes be accurately determined. These forces and moments are: *drag*, which is parallel to the airstream; *lift*, which is perpendicular to the airstream and in a vertical plane; *side force*, which is perpendicular to the airstream and in a horizontal plane; *rolling moment*, which is the moment about the drag axes; *pitching moment*, which is measured about the side force axis; and *yawing moment*, which is measured about the lift axis (see Figure 1). A balance system which measures all of these forces and moments is known as a six-component balance; most wind tunnel balances are of this type.

As may be noted in Figure 1, the model, in testing, is placed on supports which are mounted on a circular platform. This platform is in turn supported and restrained by three sets of mutually perpendicular struts which have double flexures at each end so that they are capable of transmitting only axial load and have negligible resistance to bending. These struts, in turn, transmit the forces to a system of levers which are connected to six scales, each scale measuring a particular force or moment. For example, the circular frame shown in Figure 1 is supported on three vertical struts — two lift struts and a pitch strut. The two lift struts are connected at their lower ends to a beam which is pivoted in the middle and connected to the roll scale by additional levers. The pitch strut is connected by a lever to the pitch scale. The side force, roll, and pitch systems are mounted on a single platform scale which measures the lift. The difference between the forces in the two lift struts gives the rolling moment; the force in the pitch strut gives the pitching moment; and the sum of the forces in all three struts is collected by the lift scale platform and transmitted to the lift scale to give the lift. In like manner, the yawing moment scale is mounted on the drag scale platform so that the difference in the forces in the two drag struts results in the yawing moment and a summation of the two gives the drag force.

Since the model is mounted at a considerable distance above the point on the

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WATER TREATMENT

By ROBERT S. INGOLS*

The 1948 Faculty Award of the Georgia Tech Sigma Xi Club was given, last spring, to Dr. Robert S. Ingols; his paper on "An Oxygen Consumed Test for Sewage" was chosen as the best research paper published during the past year by a member of the faculty. An important accompaniment to the financial prize is the privilege granted to the winner of addressing the faculty and friends of Georgia Tech at a Sigma Xi public lecture, held as a part of commencement week ceremonies. Dr. Ingols chose as his subject "Water Treatment," the major field of his personal endeavors, and the following article contains the major portion of this address.

Water treatment is the meeting ground of the sciences of engineering, biology, and chemistry: a field in which new information must be continually acquired in order to improve the quality of the water withdrawn from streams or discharged into them after use.

When we draw a "fresh" glass of water from the faucet, many of us have often had occasion to pause to consider why,

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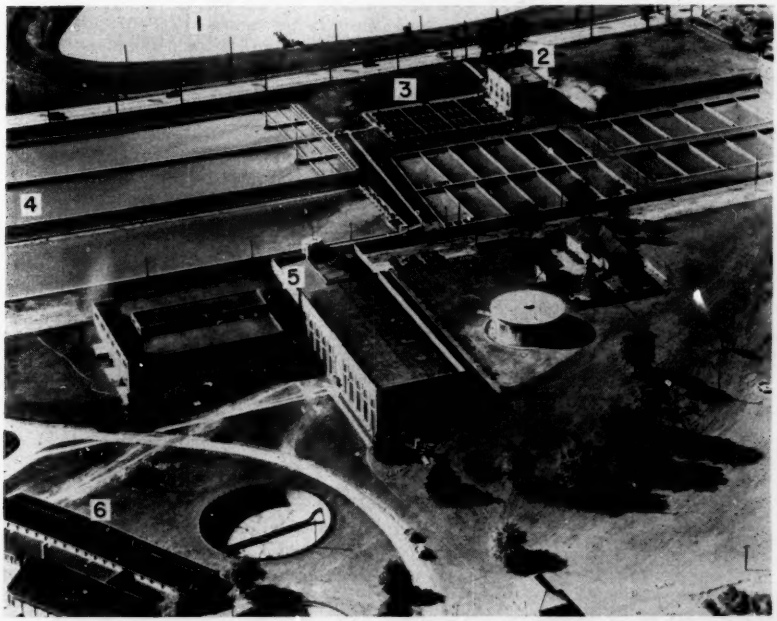

Figure 1. Atlanta Water Treatment Works. The water flows from the storage reservoirs (1) to the chemical dosing house (2), then through flocculating chambers (3) to settling basins (4). After settling, the water flows through the filter house (5), which is attached to the administration building, and then to the high-lift pumping station (6).

cheap as it may be, water should have to cost us anything. After all, doesn't the "waterworks" get its material free, add a "little too much" chlorine occasionally (perhaps just to remind us that we're being protected), and then pump it to us — an operation involving some investment and expense, of course, but surely a simple matter?

Those of us who work in the field of water treatment, however, know that this matter is neither simple nor "easy," although every effort is concentrated upon providing operating plants with methods and procedures which can be followed as readily as possible. Water must be treated primarily because its users demand a water that is safe, clear, good tasting, and soft — a combination of qualities almost never found in nature.

CLARIFICATION

Atlanta, for example, derives its water supply from the Chattahoochee River, which is muddy, unsafe for direct consumption, and, at times, poor tasting. Because of the rapid changes that can take place in a river water, it is desirable to have large storage reservoirs, such as are found in Atlanta, in order that the quality of the water may not fluctuate too rapidly for proper treatment. As the water is drawn from these reservoirs, alum (aluminum sulfate) is added to coagulate the fine cloud of mud particles into large clumps, which settle out of the water in the bottom of large tanks. This procedure has not been changed for many years, although the theoretical explanation of the mechanism involved has been modified considerably in the last few years. Most of the mud is removed by this chemical treatment and settling, but the desired sparkling clarity is not obtained until the water is filtered through beds of sand and gravel.

CHLORINATION

Although removing the mud by chemical coagulation and sand filtration also removes many of the bacteria, it goes almost without saying that everything possible must be done to eliminate *all* chance of the water carrying any disease-producing organisms. Almost universally, therefore, chlorine is added to public water supplies as an effective agent for destroying bacteria rapidly. However, if sufficient chlorine be used, some of it will often persist in the water for a long time. As a result, one may at times smell it while taking a warm shower, at time which many people unthinkingly "wish that the water plant would not use so much chemical." It has been shown, however, that proper chlorination can prevent the distribution of most of the water-borne diseases. For example, although the epidemiologists say that poliomyelitis is not a water-borne disease, they have no direct evidence to show that it cannot be carried by water, and it is now known that adequate chlorination will destroy this virus.

Those of you who may still complain about the taste of chlorinated water, while admitting the necessity for chlorination, would certainly like to see the practice of chlorination improved. Fortunately, there is in progress a great deal of research toward that end. In connection with this, our laboratory here at Georgia Tech is interested in developing better methods of analyzing the water which contains chlorine, so that water plant operators can tell more readily whether the chlorine in the water will cause excessive taste and whether it will kill the bacteria fast enough.

In reality, the use of chlorine in the treatment of public water supplies is relatively new, having been developed rapidly during World War I. As so often happens when an idea is quickly applied on a large scale, many problems arose, and the study of methods of improving the use of chlorine in water treatment has been carried out both by research laboratories and by distracted water plant operators who have had problems to lick and have been venturesome enough to try some novel approaches to the situations. Approximately 20 years ago, a number of operators in the water works field noticed that when just enough chlorine was added to the water at the plant to leave a small residual amount in the water drawn from faucets nearby, there was frequently no chlorine left in the water delivered through the longest mains. More-

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DRY BATTERY RESEARCH AT GEORGIA TECH

II. THE ELECTROCHEMICAL PRODUCTION OF BATTERY-ACTIVE MANGANESE DIOXIDE

By G. H. KISSIN *

This is the second in a series of progress reports on dry battery research at Georgia Tech. It summarizes the results of the second year of research on the synthesis of battery-active manganese dioxide and describes in some detail the electrolytic process now being tested on a semi-pilot plant scale.

As pointed out last year,[1] numerous strategic considerations are involved in the domestic availability of naturally occurring manganese dioxide (MnO_2) ore of high dry battery activity, i.e., long battery life under heavy service conditions. The Gold Coast region of Africa is the only known source of naturally occurring MnO_2 which can be employed in the construction of batteries for heavy drain service. This being the case, the increasing demand for heavy drain batteries for both military and commercial service makes it imperative that this country have available, in case of need, a suitable process for the large-scale manufacture of battery-active MnO_2 from the domestic low-grade manganese ores, such as those located in North Georgia and certain Western states. To this end, the Battery Branch of the U. S. Army Signal

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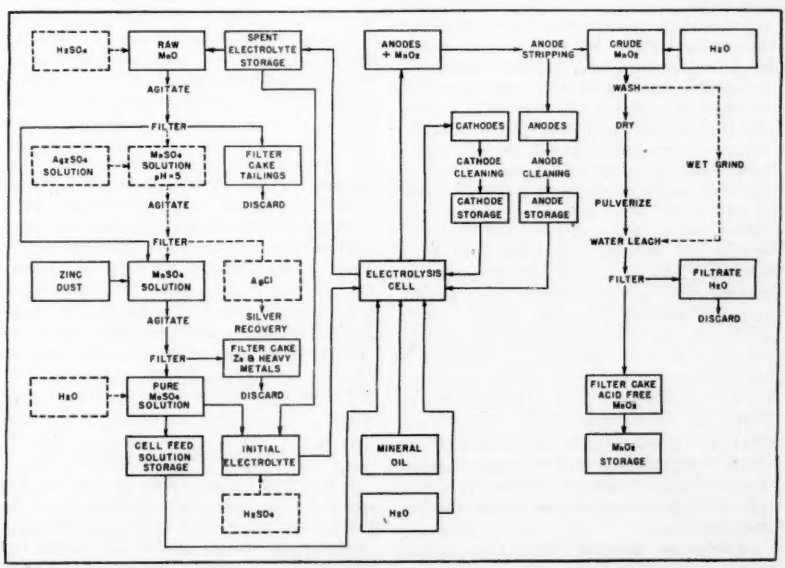

Figure 1. Flow sheet of Georgia Tech MnO_2 process. Dotted portions indicate optional steps, designed to meet special situations.

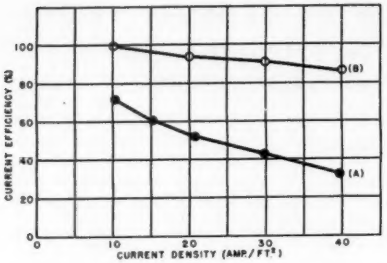

Figure 2. Comparison of current efficiency vs. current density at 95° C. for graphite (Curve A) and platinum (Curve B) anodes. Electrolyte composition: Mn (as sulfate), 50 gm./1.; H_2SO_4, 100 gm./1.

Corps Engineering Laboratories began sponsorship on June 1, 1946, of a project at the Georgia Tech Engineering Experiment Station on "Fundamental Battery Studies." This project has two main objectives: (1) the development of a process for preparing battery-active MnO_2 from domestic ores and (2) the determination of those physical and chemical characteristics of MnO_2 which are necessary for good battery activity.

Consideration of the metallurgical process requirements [1] soon led to a decision to employ an electrolytic process for the production of synthetic MnO_2; the procedure developed here is shown in Figure 1. MnO_2 is produced at the anode in an electrolytic cell by electrolysis of a solution of manganous sulfate and sulfuric acid. A small overflow of acid cell electrolyte is maintained continuously, and this acid overflow, usually referred to as spent electrolyte, is employed to leach manganous oxide, MnO, which itself may be easily prepared by furnace reduction of crude MnO_2 ores. When the leach slurry reaches a pH of 5, all major metallic impurities are precipitated as hydroxides or hydrous oxides, and filtered off. The filtrate, referred to as "neutral" or "feed" solution, is treated with zinc dust to remove the last traces of those heavy metals which are below manganese in the electromotive series.

This pure, neutral, manganous sulfate solution is fed continuously to the electrolysis cell at such a rate that manganese removed by anodic deposition (as MnO_2) is replenished and the cell electrolyte composition is maintained constant during operation. Anodes are removed periodically from the cells for stripping of the MnO_2 product, which is leached with water for removal of occluded or adsorbed acid, then dried, ground, and packed for shipment to the Squier Signal Laboratory for the manufacture of test batteries.

METALLURGICAL PROCESS CONSIDERATIONS

A study of the prior art in methods of producing battery-active MnO_2, together with early experimental results from this project, indicated that electrolytic methods generally produced MnO_2 of high battery activity. However, all of the electrolytic processes described in the literature,[2,3] as well as those inferred to be presently in use by a number of industrial concerns, are relatively inefficient, high-cost operations. Graphite anodes are generally used, and the anode current density employed is in the range of 8–15 amp./sq. ft. The acid content of the electrolyte is low, generally less than 50 gm./1. of H_2SO_4.

From the economic point of view, an electrolytic process would be most favorable when the electrolytic cells are operated at the highest possible current density and electrolyte acidity concomitant with good anode current efficiency and the achievement of desirable battery properties of the product. These features would permit maximum output for a given cell room capacity and would also decrease the total volume of solution to be handled in the leaching cycle and the plant circuit in general. Most of the effort in the second year's work on this project has been directed toward a laboratory study of those factors which might make possible a more efficient electrolytic process than the conventional low acid, low current density procedure now in use.

EXPERIMENTAL WORK

Electrolyte acidity, anode current density, and cell temperature have all been found by previous workers [3] to exert an important influence upon the anodic oxidation of manganous ion in acid solution. Since the

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DIGESTS OF GRADUATE THESES

AERONAUTICAL ENGINEERING
1947–48

Digests are presented on fatigue studies of 24-ST and 24-ST Alclad sheet having various surface conditions; a direct method for calculating the thrust and torque of a helicopter in vertical ascent; electric strain gage analysis of stress concentration in sheer panels with access holes; experimental determination of aerodynamic characteristics of cylindrical and spheroidal bodies of revolution; strain measurements in thin shear web aircraft type beams; and a study of the double venturi principle in its application to high-speed wind tunnels.

Every engineering institution which provides an opportunity for graduate study and research inevitably collects an invaluable library of theses submitted in partial fulfillment of the requirements for graduate degrees. All too often, however, those theses submitted for Masters' degrees are permitted to lie unused on the shelves, save for the few that are published, and even doctoral dissertations are not always accorded the attention they merit.

In recent years, graduate study at Georgia Tech has been proceeding at a greatly accelerated pace. In 1947–48, for example, 117 students were recipients of Masters' degrees, compared with 34 in 1946–47 and a total of 147 from 1925 through 1946, inclusive. Enrollment during the current year indicates that the Division of Graduate Studies is engaged in the most active program since its inception, especially since the School of Chemical Engineering will probably grant the doctorate this year to several students — the first to receive this degree at Georgia Tech — and several other schools will shortly be ready to permit study for the doctorate in their particular fields.

Under these circumstances, THE RESEARCH ENGINEER has deemed it fitting to begin the publication of a series of digests of the theses submitted to the various schools. During the current year, digests will be presented of some of the outstanding theses submitted in 1947–48 to the Schools of Aeronautical Engineering, Chemistry, Chemical Engineering, Electrical Engineering, Physics, and Textile Engineering. All theses so abstracted are available for consultation, if desired, in the Georgia Tech Library and the schools to which they were presented.

The following are abstracts of theses submitted during 1947–48 in partial fulfillment of the requirements for the degree of Master of Science in Aeronautical Engineering:

Aleck C. Bond, *Fatigue Studies of 24-ST and 24-ST Alclad Sheet with Various Surface Conditions.* Faculty advisor: Professor G. K. Williams.

Although the various components of aircraft are designed to withstand certain calculated loads, and it is assumed that the limits of these loads are never to be exceeded in the normal specified operation of the aircraft, failure of these components may occur due to fatigue. One of the major causes of such failure in sheet components is the scratching of sheet surfaces, a result of handling and fabrication.

A great deal of work has been carried out on surface scratches and varying degrees of finish on various steels, but the data available on present-day aluminum alloys, the primary materials in aircraft manufacture, are indeed meager. This investigation was therefore concerned with the study of the effects of surface scratches on the fatigue strength of aluminum alloys.

Fatigue studies were made on two common structural aircraft materials, 24-ST and 24-ST Alclad, with respect to various surface conditions. Only one gage of the two materials, 0.040 inch, was used throughout the investigation. Various abrasives: crocus cloth; numbers 240, 180, and 100 Aloxite Finishing Cloth; and number 60 sandpaper were used to impart scratches

of different depths to the surfaces of the metal specimens.

From the fatigue results obtained, average stress concentration factors resulting from each scratch pattern imparted by the various abrasives were calculated. The repeated flexure fatigue strengths of the alloys for surfaces scratched with the several abrasives were presented, also the curves of the relation between the average depths of the scratches and the concentration factor for repeated flexure fatigue.

The results of this investigation formed the basis for the conclusions that surface scratches definitely reduce the flexure fatigue strength of the two materials studied and that the greater the depth of surface scratch, the greater the reduction in strength. The stress concentration factors reported are reliable for application to design for design conditions similar to those of the investigation and should be applied in computing margins of safety. *M. B.*

Fred B. Culwell, Jr., *A Direct Method for Calculating the Thrust and Torque of a Helicopter in Vertical Ascent.* Faculty advisor: Professor Walter Castles, Jr.

The object of this investigation was to find a more convenient and sufficiently exact method for calculating the thrust and torque of a helicopter in vertical ascent.

Equations for the general case of rotors having blades with any twist and taper were derived by a combination of the momentum and blade element theories. A semi-empirical constant, k_1, which corrects for the effects of viscosity, was introduced. Several simplifying approximations were made in order to obtain a direct solution.

The thrust and torque coefficients were calculated from the theory for a particular model rotor on which test data were available. Results obtained are satisfactory for the special case of hovering flight and at low rates of vertical ascent, but, for higher rates of vertical ascent, the theoretical values of the thrust coefficients are progressively higher than the experimental values. The theoretical torque coefficient values are in good agreement with the experimental values over the whole range. *M. B.*

John Henry Kouns, *Electric Strain Gage Analysis of Stress Concentration in Shear Panel with an Access Hole.* Faculty advisor: Professor G. K. Williams.

When metal is used as a construction material, it is very often necessary to cut access holes in shear panels to facilitate assembly and inspection and to permit the installation of plumbing and control cables, but, until recently, little has been done to determine the stress pattern and values of the stresses in these shear panels.

The purpose of this study was to determine more precisely the quantitative values of the stress concentration factors and the primary axial and secondary bending strain induced in panels by access holes. From the work done at Georgia Tech by William H. McKee with Stresscoat, the areas of maximum stress were known to be at the edge of the hole parallel to and perpendicular to the diagonal tension buckles. The points of maximum stress were the ones of interest; therefore, electric strain gages were located at the edge of the hole in these areas, and strains were measured.

Pure shear tests were made on a number of ten-inch-square panels of 24-ST and 24-ST Alclad sheet aluminum alloy having various gage thicknesses and hole diameters to determine the stress concentration at static rupture and the strain characteristics around the hole. *M. B.*

Robert Weaver Rainey, *Experimental Determination of Aerodynamic Characteristics of Cylindrical and Spheroidal Bodies of Revolution.* Faculty advisor: Professor H. W. S. LaVier.

A study of existing information on bodies of revolution indicated a general lack of experimental data on lift, drag, and moment with a variation of angle of attack.

Accordingly, a number of cylindrical bodies of revolution with bluff, conical, and hemispherical noses and spheroidal bodies of revolution were tested in a 30-inch wind tunnel. All models tested were of the same maximum cross-sectional area; consequently, for a definite length/diameter ratio, every model had the same length and diameter. A constant wind velocity of 97 feet per second was used in all tests, and the forces were measured by use of a strain gage balance system.

As a result of these tests, it was possible to compare in coefficient form the relationship of lift, drag, and moment of the various models. *E. P. C.*

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RECENT STATION PUBLICATIONS

CIRCULARS

B. H. Weil. *Detergents from Petroleum.* Georgia Institute of Technology, State Engineering Experiment Station Circular No. 22, 1948. 8 pages. Gratis.

Petroleum refining no longer is restricted to the production of fuels and lubricants. In the synthetic detergents field, for example, petroleum fractions are already playing the dominant role as basic raw materials, and more and more petroleum companies are entering the synthetic detergents field, alongside of chemical companies which are themselves employing petroleum materials.

This reprint of an article from *Petroleum Refiner* reviews the principles of detergent action and describes in some detail the important petroleum detergents. Among these are the alkyl aryl sulfonates and the alkyl sulfonates, while the equally important alkyl sulfates are capable of synthesis from petroleum or Synthine intermediates, as is soap itself. The article concludes with an analysis of the basic economics of the entire field.

Much confusion exists in the synthetic detergents field, since hundreds of surface-active agents are already in existence, many of which are not general-purpose detergents and are suitable only for special uses. Recent advances in technology have been such, however, that there appear to be few valid reasons why synthetic detergents will not offer a real threat to soap production in the next few years.

B. H. Weil. *Technical Information Service at Georgia Tech.* Georgia Institute of Technology, State Engineering Experiment Station Circular No. 23, 1948. 4 pages. Gratis.

Modern industry — large and small companies alike — has long since recognized the need for research and development assistance, and, more recently, has become increasingly aware of the value — economic and technical — of having available adequate information to guide both research and operational activities. At Georgia Tech, internal needs resulted in the creation of a Technical Information Division in 1945, and this group now offers a variety of services to industries and individuals of this region.

Among these services, according to this reprint of an article from the August, 1948, issue of *Manufacturers Record*, are the preparation of information searches and information summaries and the provision of a variety of current information services. Access to the excellent Georgia Tech library and to specialized libraries in this region affords adequate material for work in many fields to the staff of the Technical Information Division. Information work has already been performed by this group in the fields of food freezing, water and sewage analysis, dry cell technology, solvent extraction of oilseeds, textile lubricants, lubricant re-refining, etc. *B. H. W.*

Georgia Tech Engineering Experiment Station, 1947-48. Georgia Institute of Technology, State Engineering Experiment Station Circular No. 24, 1948. 3 pages. Gratis.

This reprint of an article from the August 23, 1948, issue of *Chemical and Engineering News* describes in considerable detail the 1947–48 project work of the Station in chemical and chemical engineering fields. Under "Methods Research" are listed projects on food freezing, water and sewage analysis, battery studies, vegetable oil studies, cellulose studies, chlorination of raw sewage, and spectrographic determination of iron and titanium in kaolins. Projects classed under "Materials Research" dealt with properties of matter at very low temperatures, thermodynamic properties of gases, weed killers, development of explosives, particle size distribution in a nebulizer mist, and pipe line corrosion tests.

"Textile Research" projects included studies of yarn processing, ramie processing, nylon staple research, textile processes, and mechanical disorientation of cloth layers. Projects classed under "Engineering Design" included the design of a gas producer, a null-type manometer, and a gasoline engine of unique combustion cycle. Numerous literature searches were listed under "Technical Information." Details given of the Station's growth and

general activities are similar to those published in the article on the Station in the September, 1948, issue of THE RESEARCH ENGINEER. *B. H. W.*

REPRINTS

Walter Castles, Jr., and Arnold L. Ducoff, *Static Thrust Analysis for Helicopter Rotors and Airplane Propellers*. Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 24, 1948. 7 pages. 25 cents.

This paper, reprinted from the *Journal of the Aeronautical Sciences*, presents a solution for the relation between the blade angle, thrust, and torque coefficients of a heilcopter rotor in hovering flight. This analysis presents the case wherein the included velocity at a given radius, r, is set up as a function of the thrust at that radius and a semiempirical constant, k_1, is introduced to account for the viscous shearing forces in the flow. Equations have been derived which yield, upon graphical integration, the thrust and torque for the general case of blades with any solidity, twist, or taper. The solutions for the integrals of the equations for the special case of a constant chord, untwisted blade are also presented. The results apply to a helicopter operating in or out of ground effect, and values of the semiempirical constant, k_1, which have been calculated from experimental data, are presented for the entire range. This method gives values of the thrust and torque coefficients which are in good agreement with the available experimental data. Since the static thrust case of an airplane propeller is identical to that of a helicopter rotor in hovering flight, this method can be used for the calculation of the static thrust and torque of modern variable pitch propellers.

Alan Pope, *On Airfoil Theory and Experiment*. Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 25, 1948. 4 pages. 25 cents.

In this article, reprinted from the *Journal of the Aeronautical Sciences*, the more exact equation for the slope of the lift curve is restated, and a relation for the location of the aerodynamic center is advanced. An approximate method for determining the minimum drag coefficient and extent of the low drag bucket is also given.

F. Bellinger and T. W. Kethley, *Frozen Food Research Program Is Launched at Georgia Tech*. Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 26, 1948. 4 pages. Gratis.

Because of their mutual interest in the development of industry and agriculture in the South, the Tennessee Valley Authority and the Georgia Tech Engineering Experiment Station have established a long-range program on the fundamentals of food preservation by freezing. In this article, reprinted from *Food Industries*, the scope of the program is outlined, and some discussion of the principal phases of the work is presented.

The Georgia Tech program is concerned with problems of blanching, the selection of media for immersion freezing, histological and colloidal changes during freezing and storage, determination of optimum storage conditions, perfection of packaging materials, etc. Many analytical techniques have had to be developed in order to control the experiments in a scientific manner. This article includes a brief survey of the literature on blanching, color changes, immersion freezing, freezing rate, and microscopic techniques.

W. T. Ziegler, *The Superconductivity of Lanthanum and Cerium*, Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 27, 1948. 1 page. Gratis.

This contribution to the *Journal of Chemical Physics*, August, 1948, reports measurements of the variation with temperature of the magnetic permeability of lanthanum and cerium. Two different samples of the former exhibited magnetic transition into superconductivity at $4.85 \pm 0.15°$ K. and $4.45 \pm 0.10°$ K; in each instance, the transition occurred over a range of less than $0.1°$. For cerium, no evidence of superconductivity was observed down to $2°$ K., the lowest temperature reached. These results are compared with data reported by earlier experimenters. *B. H. W.*

Harold T. Coss and James L. Taylor, *Ramie Today*, Georgia Institute of Technology, State Engineering Experiment Station Reprint No. 28, 1948. 11 pages. 25 cents.

This reprint of an article from *Textile Industries*, August, 1948, comprises a well documented report on detailed laboratory and pilot plant experiments conducted at Georgia Tech and at the Johns-Manville Research Center on the processing of ramie

fiber. While much has been published on this subject, the authors state that almost all of the generally available data were old and conflicting, and little information was available on processing ramie on cotton mill machinery.

The authors studied ramie fibers from several sources, and developed several degumming processes which could be used with close control. Proper opening of the fibers after degumming was found to be difficult, and special adjustments must be made in cotton mill equipment before ramie fibers can be spun. Ramie, cotton, and linen fabrics were compared as to strength, brittleness, resistance to flexing and residual shrinkage, "coolness," etc.; ramie fibers proved equal or superior to the other fabrics on almost all counts.

According to the authors, there is little likelihood that ramie will materially replace cotton, even when handled as stapled fiber on ordinary cotton mill equipment. However, "it is possible to make fabrics from staple ramie that would equal or even outperform line flax fabrics (linen) in general wear resistance, and would compare favorably with linen in appearance and hand. Ramie is especially suitable for use in high-grade specialty fabrics, where a premium in appearance or serviceability is attractive and desirable." *B. H. W.*

SPECIAL REPORTS

Marjorie Bolen and B. H. Weil, *Literature Search on Dry Cell Technology*. Georgia Institute of Technology, State Engineering Experiment Station Special Report No. 27, 1948. 708 pages. $5.00 in U. S.; $5.50 foreign.

Dry cells have long been in use, but, as for most articles of manufacture, research is still needed on many technical phases, such as performance, shelf life, etc. All of these, in turn, depend upon the raw materials employed, and it is on the synthesis of one of these — battery-active manganese dioxide depolarizers — that Georgia Tech research is now centered, in a research program sponsored by the Battery Branch of the U. S. Army Signal Corps Engineering Laboratories.

Since all phases of dry cell technology must be considered in a thorough analysis of work on any part of the subject, it was decided to precede experimental work with a thorough study of the published literature on dry cells, with special reference to manganese dioxide and methods for its synthesis.

This literature search offers ample evidence of the volume of literature in this field, hence the need for its collection and organization. The more than 3,800 references included, plus a 60-page alphabetical subject index, constitute an indexed, expanded bibliography of the pertinent literature dealing with dry cell technology, manganese ore deposits throughout the world, and methods of treating such ores for the preparation of battery-active manganese dioxide depolarizers. Before publication, the coverage of the search was extended to January 1, 1948.

B. H. Weil, Poagie E. Murray, George W. Reid, and Robert S. Ingols, *Bibliography on Water and Sewage Analysis*, Georgia Institute of Technology, State Engineering Experiment Station Special Report No. 28, 1948. 215 pages. $4.00 in U. S.; $4.50 foreign.

Methods of water and sewage analysis are of importance to water and sewage plant operators (municipal and industrial); federal, state, county, and city health agencies; research laboratories; educational institutions; and consulting engineers and chemists. As is evident from the more than 2,600 references included in this bibliography, much scientific attention has already been given to the manifold aspects of the subject, but it seems clear that, while work in this field has been conducted at an accelerated pace in recent years, there is a definite need for additional research, even on tests which have become "standard methods."

The *Bibliography on Water and Sewage Analysis* constitutes an indexed guide to the pertinent literature on water and sewage analysis, prepared so that future work might benefit through use of and acquaintance with existing data. References have been sorted according to subject under "tests" for various materials and properties. Access to references on "methods of analysis" and related subjects has been made possible by lists of the pertinent reference numbers. References are numbered consecutively throughout the book, and all items include bibliographic reference to abstracts where these are known to exist. An author index is included. *B. H. W.*

WIND TUNNEL BALANCE

Continued from Page 4

circular frame at which the horizontal forces are taken out, a pitching moment is introduced by the drag and a rolling moment by the side force. The pitch caused by the drag is subtracted by a differential gear train connecting the pitch and drag indicators in the control panel, and the rolling moment caused by the side force is compensated for by an integrating linkage which connects the roll and side force systems and introduces an equal but opposite moment in the roll beam.

Forces and moments are measured on electronically controlled beam balances, shown in Figure 2. The beam poise is driven by a motor mounted on the beam which receives its power from grid-controlled thyratrons. Two speed ranges are provided, the lower speed taking over automatically for the final balancing of the beam. This speed control is accomplished by means of a phase shift on the thyratrons. Contacts at the free end of the beam control the speed and direction of the poise travel. If the poise travel proves to be insufficient to balance the beam in either direction, limit switches are actuated which cause unit weights to be added or subtracted until the beam reverses. At this time the poise, which has been locked out, again takes over and balances the beam.

A selsyn transmitter is also mounted on the scale beam and geared to the poise actuator lead screw. The receiver of the selsyn is connected to one side of a differential gear train, and the motor which drives the unit weight system is geared to the other side. By means of this differential gear train, the summation of the balancing load on the beam (due to the poise and the unit weights) is fed into a second selsyn transmitter. This transmitter is connected to a selsyn receiver in the control panel which drives a Veeder Root counter and indicates the load on the scale, directly in pounds in the case of the three scales reading forces and in foot-pounds for the scales reading moments.

Each scale beam is connected to a dash-pot having variable damping. The connecting linkage is so arranged that a small movement of the beam results in a large movement of the dash-pot piston.

Figure 3. Front view of control panel showing force indicator dials (upper center) with the two angle indicator dials directly below. Controls are arranged outward from the center in order of decreasing use. The vernier manometer (sitting left center) is used to indicate the wind velocity; this is to be replaced with an automatic indicator which is being developed.

Most of the force systems had a high degree of inherent stability which resulted in low sensitivity. To overcome this, destabilizing weights were mounted on the dash-pot cross arm as shown in Figure 2. The weights are adjustable in a vertical direction so that any degree of stability from positive to negative can be obtained. Optimum operating conditions were found to occur when the system had a very slight degree of positive stability.

The control panel, shown in Figure 3, is the nerve center of the wind tunnel balance. From this panel, the tunnel operators can control the functions of the balances and all the auxiliary equipment as well as read the forces on the model. From this station the attitude of the model may be changed about both the pitch and yaw axes by use of 220-volt, three-phase, fractional-horsepower gear motors. Selsyn repeaters indicate the attitude of the model to 0.01 degree. To aid reading, a single switch locks all force dials simultaneously so that the instantaneous readings are retained while the data are being recorded. To facilitate maintenance, all electrical connections are made either at terminal blocks or by means of multi-prong plugs.

INSTALLATION AND CALIBRATION

Approximately six months was required for the installation and calibration of the balance. During the latter part of this time, some test programs were conducted, and several minor modifications were made as a result of the experience gained on these tests.

For the erection of the balance, longitudinal and transverse center lines were established in relation to the wind tunnel test section. The various components of the balance were then put in place, a tolerance of $\pm$ 1/64 inch being maintained. Final adjustments were made by applying loads to the system and noting the error in the various forces and moments. The basic problem was to adjust the strut systems so that they were mutually perpendicular and introduced no components from one force system into another. A loading tee was mounted on the model support system, as shown in Figure 4, and was provided with attachment points so that all six components could be loaded either independently or simultaneously. In order that the inaccuracies due to the loading tee would be small compared to the desired accuracy of the balance, it was found necessary to maintain the location and alignment of the loading points within $\pm$ 0.005 inch.

Figure 4. View of calibration tee mounted for calibrating the balance. In testing a model, the direction of the wind is from left to right across the picture. The side force calibration pulley can be seen in the background. Maximum-design side force and drag loads are never experienced under actual test conditions with the type of mount shown; therefore, it was necessary to cross-brace the supports to prevent excessive deflection of the calibration tee.

Weights to produce lift, roll, and pitch were hung directly on the tee frame. Side force drag and yaw were applied by cables which passed over large diameter pulleys mounted in precision ball bearings. These pulleys were aligned within $\pm$ 1/32 inch horizontally and $\pm$ 1/64 inch vertically. At the distance these pulleys were mounted from the loading points on the tee, this misalignment represents a maximum possible error (which might appear in any of the force systems which were not being loaded) of less than 0.04 per cent of the applied load.

A preliminary study of the problems of calibrating the balance indicated that a definite loading sequence would be advantageous. This sequence was based on the complexity of the linkages in the various force-measuring systems, that system being loaded first which was the least complex and offered the least possibility of having extraneous forces introduced from misalignment of the rest of the system. Having established this loading sequence, the calibration then became a matter of applying a known load to one force system and noting the component of that load which appeared in the other force systems. The struts in the system being loaded were then adjusted to eliminate these components. In most cases, the systems were so interconnected that after making a correction in one system it was necessary to go back and reload the other systems, the errors being eliminated in a series of successively smaller steps.

Under many conditions of testing, the forces acting along one axis may be very small compared to the forces acting along or about the axes which are perpendicular to it. For instance, it may be desirable to detect a very small side force under conditions where lift and drag are several hundred times as great. This makes it mandatory that the interaction of forces be not merely small but actually must be practically nonexistent. As a result, many of the final adjustments were in the order of $\pm$ 0.005 inch. After the calibration was

completed, all struts were securely bolted and taper pinned in place.

LOADS AND ACCURACY

The Georgia Tech Wind Tunnel Balance, while not the largest in this country from the standpoint of either physical dimensions or load-carrying ability, is believed to be the most accurate for its size and the first of its type to be put into operation.

Based on the maximum size of the models that can be tested in the tunnel and on a test wind velocity of 150 miles per hour, the balance was designed for the following limit loads:

Lift	± 1600 pounds
Drag	± 400 pounds
Side Force	± 800 pounds
Pitching Moment	± 500 foot-pounds
Yawing Moment	± 1200 foot-pounds
Rolling Moment	± 1200 foot-pounds

The maximum allowable error was specified to be 0.1 per cent of the poise beam capacity or 0.1 per cent of the applied load, whichever was greater. This specification resulted in the following desired accuracies in the lower load range, which is governed by the poise beam capacity:

Lift	± 0.10 pound
Drag	± 0.05 pound
Side Force	± 0.10 pound
Pitch	± 0.20 foot-pound
Yaw	± 0.125 foot-pound
Roll	± 0.125 foot-pound

As evidenced by Figure 5, errors in the balance system have been reduced to values considerably lower than the specified limits; this has been particularly true in the higher load range. Figure 6 gives curves of lift and drag versus angle of attack for a symmetrical airfoil. The points on these curves were calculated from data read during actual test programs.

The new balance system with its auxiliary equipment makes the Georgia Tech Nine-Foot Wind Tunnel one of the most versatile in the country. Four different jet configurations may be used in combination with five different types of model mounting systems. The jet configurations are: a nine-foot circular open jet, a nine-foot circular closed jet, a seven- by nine-foot rectangu-

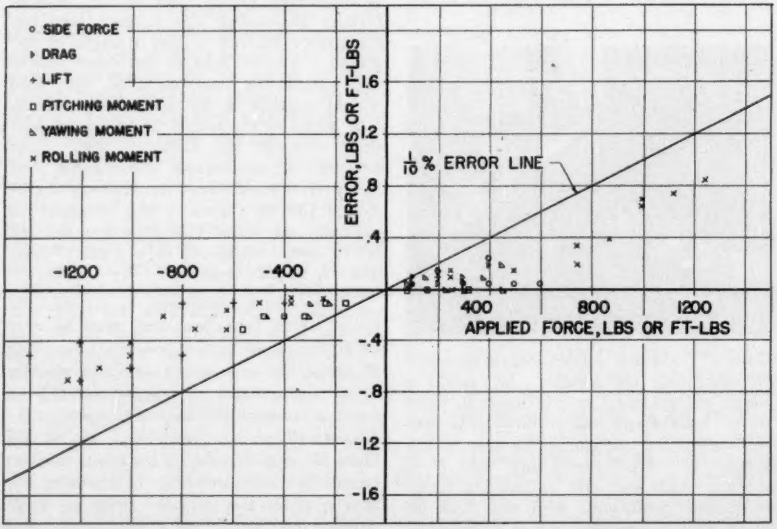

Figure 5. Plot of actual error versus applied load for the six-force systems. The straight line indicates the maximum permissible error of 0.1 per cent of the applied load.

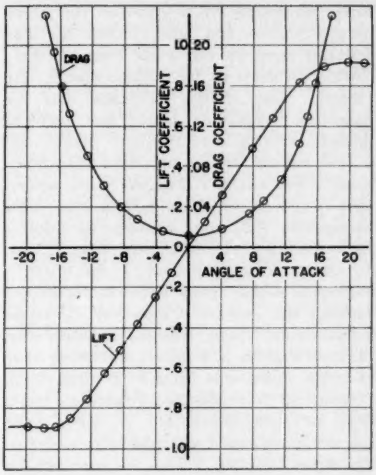

Figure 6. Typical data obtained with the balance under actual test conditions, for a symmetric airfoil run at 100 mph.

lar section closed jet, and a two-and-one-half by seven-foot rectangular closed jet for two-dimensional testing. The model mounting systems are: three-point support, single support, panel mount, helicopter rotor test stand, and propeller test stand.

The versatility of this tunnel offers the staff and students of the School of Aeronautics the opportunity to engage in or be associated with a wide variety of research problems, both of an applied and fundamental nature. With the added facilities of its new balance system, it may be anticipated that the Georgia Tech Wind Tunnel will continue to serve government and industry by making possible the undertaking of important programs in both categories.

WATER TREATMENT

Continued from Page 6

over, it was found that adding a small additional amount of chlorine at the plant simply caused complaints from those water consumers who lived near it and still did not improve the distribution of chlorine to distant points.

This lack of chlorine in the mains is undesirable for two reasons; first, it permits slime bacteria to grow in the mains, and second, there is no protection against any chance contamination, such as may enter the mains in areas in which a failure in water pressure occurs. Slime bacteria are harmless in themselves, but annoying because they can corrode the pipes and change the water so that it will cause rust stains on clothes laundered with it. These slime bacteria also cause many a water works superintendent to have sleepless nights, for if these bacteria are killed, perchance, by an overdose of chlorine, or intentionally by an improvement in chlorination, then their dead bodies will be carried by the water to the faucets. Needless to say, even dead bacteria can be very offensive to the consumer, and "howling" water consumers may look for a scalp.

It was soon found, however, that if ammonia was added to the water, along with less chlorine than previously used, chlorine could be detected much longer (or farther out in the mains) than if chlorine alone had been used. Ammonia is inexpensive, moreover, so a little money could be saved. Thus, many water supply systems adopted the use of the ammonia-chlorine compound called monochloramine, the chemical which you may have smelled while taking a recent shower or bath. However, while the persistence of the chloramine in the water is highly desirable, it is unfortunately true that the same reaction which makes the chloramine last longer makes it a poorer or slower bactericide, and it does not always control the growth of slimes.

NEW CHLORINATION METHODS

It was not until about ten years ago that a means was discovered of adding chlorine to water so that it would persist in the mains and yet give the highest necessary rate of bacterial kill. At that time, means of analyzing for different kinds of chlorine were not yet known, so that adoption of this new method lagged for several years, because its merit was not quantitatively understood. Today, rapid field methods for determining the different kinds of chlorine

solutions are available, and many new plants now use the more powerful, yet persistent, solutions of chlorine. This new "trick" simply involves the use of much more chlorine than in the early days, without, paradoxically, leaving more in the water which leaves the plant; the extra chlorine destroys the ammonia and some of the organic materials, so that only pure chlorine is left in the water.

Strangely enough, pure chlorine in pure water does not cause any taste or odor even when nearly ten times the amount normally used is employed. This fact permits an operator to use an adequate amount of chlorine, except when foul-tasting compounds are formed by the reaction between chlorine and certain organic materials which may be present — or if there are no limits to his chlorine budget. Here again, in many cases, the taste situation is improved by the use of the larger amounts of chlorine. This factor has inspired the use of this new, so-called "breakpoint" method of using more chlorine in many plants, while the improved safety has often been accepted merely as a desirable by-product.

Atlanta is truly fortunate in being near a river whose watershed is undeveloped industrially; this permits the chlorination of the water without the production of a medicated taste and a fishy or burnt odor, except for a few weeks out of the year; even then these are mild enough that they can be controlled. Some cities such as Niagara Falls, New York, or Saginaw, Michigan, receive water which has a very heavy chemical content and which develops a medicated taste when it is chlorinated. The new method of chlorination, however, has improved the taste of the water supplies for these cities and has been used by them, in spite of its increased cost.

Approximately four years ago, one of the large commercial producers of chlorine suggested the use of another chlorine treatment modification, designed primarily for controlling the taste of the water. In this case, chlorine is reacted with a chlorine compound, sodium chlorite, to form chlorine dioxide which has properties which are an improvement over some of the desirable characteristics of chlorine itself. It will persist longer in the mains, will be a better bactericide than chlorine for many potable waters, and will produce less undesirable odors in the water from its reactions with some of the organic matter. At present, most of the published data are based on laboratory work, but chlorine dioxide is being used in many plants, and a few reports on its use have been published. For example, Niagara Falls reports that it can use chlorine dioxide even more successfully than large amounts of chlorine in controlling the medicated taste caused by the presence of phenol in the water, a statement which agrees with the laboratory findings for phenol. However, a recent article from South America indicates that chlorine dioxide is a poorer bactericide than chlorine. This may agree with some of the conclusions from laboratory findings, but it was not anticipated for a water good enough for a public water supply, according to recent research. The use of chlorine dioxide is definitely on an experimental basis, as yet, but it does hold the promise of helping the water works operator to supply a better-tasting water. In addition, chlorine dioxide is less volatile than chlorine, so that one would not smell it as readily.

Ozone could be used in water, for it is an excellent bactericide and virucide, but it is so unstable in water solutions that it does not persist in the distribution system long enough to give protection against new contamination or to prevent the growth of the slime organisms on the iron pipes; moreover, it is more expensive than chlorine.

Only those problems involved in providing Atlanta with safe, clear, and odor-free water have so far been discussed. In Atlanta, the only other water treatment required is the addition of the correct amount of lime to prevent the water from corroding the distribution pipes. Today, this addition is controlled by automatic electronic machinery designed to keep what the chemis. calls the pH of the water between 9.3 and 9.5. The lack of iron rust on household fixtures is a good index of success here in controlling corrosion.

WATER SOFTENING

Having discussed the problems involved here in producing a suitable water, it is now

timely for us to consider some of the problems encountered elsewhere. Atlanta is particularly fortunate in having a "soft" water, for all of us can obtain a lather very easily in a bath or in the laundry, yet the water does have sufficient hardness to enable us to wash out the suds. Sad tales of hard-water areas are so common that it may be hard to realize that there is actually a small town in the northern part of this state which has such soft water that it has to add lime just to make the river water hard enough for household use.

On the other side of the picture, however, we have such communities as Ann Arbor, Michigan, where the well water supply at one time had a hardness that was thirty times that in Atlanta (450 p.p.m.). To remedy this, the community installed water softening units, but, in the meantime, it had to use this water for washing. While inhabitants soon found that there are new detergents on the market which can clean things with hard water just as though it were soft, and that these new detergents have thus taken much of the horror out of hard water for the housewife, this still does not mean that soft water, or water softening, is not necessary or desirable.

The softening of water for large towns has been accomplished, for a long time, by adding lime and soda ash, the softening being accomplished by simple reactions that are studied in freshman chemistry. Recently, however, it has been possible to install units of zeolite filters in small towns or even in homes. These small filters can be correctly operated with reasonable economy even by untrained personnel, and are now widely sold in hard water regions. The zeolite can be either a sand which is mined in certain areas or a plastic which has been developed synthetically.

Many towns near the swamp areas of the Atlantic seaboard have the special problem of color in their available potable water supply. This problem may be overcome by the same techniques that are used to remove muddiness from water; i.e., chemicals are added, and the water is then filtered.

ADDITION OF FLUORIDES

Recently, a very interesting experiment in water treatment has been started. Since January, 1945, the water treatment of several towns has included the addition of sodium fluoride in very small amounts (2.0 p.p.m.). This salt is being added on an experimental basis under the supervision of the United States Public Health Service, in order to determine, over a long period of time, whether any noticeable improvement can be made in the number of carious teeth (those that require filling by a dentist) in school children.

A large number of towns in very similar financial and sociological circumstances have already been studied. Thus, several adjacent North Shore communities of suburban Chicago have been surveyed. Some of these towns use Lake Michigan water, which contains no fluorides, while the others choose to use well waters which, it develops, have what is considered to be just the right amount of fluorides. The evidence in these towns, divided only by arbitrary boundary lines, shows that the teeth of the children in the towns that have well water with the right amount of sodium fluoride are much better than the teeth of the children in the adjoining towns which use the lake water which does not contain fluorides. No final announcement of any of the dental studies concerned with deliberate addition of fluorides has yet been made, but preliminary reports from New York State are very favorable. Until some of these studies have been definitely completed, however, many dentists and men in the water works field are opposed to the idea of adding fluorides elsewhere without careful control. Thus, the field of water treatment has expanded into the field of dentistry!

Our own research laboratory here at Georgia Tech is vitally interested in working out a technique for the rapid and accurate determination of fluorides that are present in or added to the water.

OTHER FACTORS

Those factors discussed thus far have been those which are important to supplying the water used in homes. However, much of the water pumped from the Chattahoochee River in the Atlanta area is used by the industries of this region. Is the quality of water needed by these industries any different from the quality of water

needed in the home? Yes, for in some industries the water used in the production of their products must be purified to a very high degree, such as by distillation, while others are more interested in receiving large quantities of water at the lowest unit price, without regard to quality. As an illustration of the high quality of water sometimes needed, one might mention the water used for preparing sugar saline solutions which are to be injected directly into the patient's blood stream in emergencies. On the other extreme, the Georgia Power Company uses huge amounts of Chattahoochee River water at its large power generating station alongside of the river, west of Atlanta, without any treatment at all. Here, the power company pumps the water over its steam condensers and allows it to return to the river unchanged, except for a rise of a few degrees in temperature. Even the power company, however, must treat a relatively small amount of river water to a high degree before adding it to its steam boilers, because here the chemical engineer and mechanical engineer are vitally interested in the response of the boilers and turbines to the chemical nature of the water added.

The most desirable chemical characteristics of an industrial water supply must, in general, be worked out for each individual plant, and many industries take the same water that is supplied to homes and modify it still further for their needs. Some industries, in the past, have located their factories in accordance with the best available water supply. Thus, the textile industry was first located in the northeast section of this country, where there were many nearly perfect water supplies (plus good workers). Now, with many sociological changes taking place, and with technologists able to provide water of the quality needed, the textile industry is moving nearer to its source of raw materials — as we hope that it will continue to do.

INDUSTRIAL WASTES

What are some of the implications of this movement of the textile industry to the South? Following the textile industry, we might well expect that dye manufacturing firms will move some of their plants to this region. What effect would these dye manufacturing plants have on the rivers receiving their waste water? I have watched the Raritan River many times during my work and study at Rutgers University, in New Jersey. The Calco Chemical Company, a large manufacturer of dyes, is located upstream from Rutgers on the Raritan, and has recently built a large, expensive waste-treatment plant, yet the waters of the river at New Brunswick are ever changing in color.

Recently, Herty Day was again celebrated in Milledgeville at the Georgia State College for Women in honor of the man who did much to establish in this region paper manufacture from the forests of the South. This vitally important industry uses tremendous quantities of water, adds large amounts of organic matter to the water, and discharges this water into nearby lakes or rivers. Fortunately for fishermen, most of these paper plants have been located along the coast — fortunately also for others, for at least one stream in New England has become so polluted that the rotten-egg odor of hydrogen sulfide has practically ruined whole towns miles downstream from two paper mills. What is the remedy? Thousands of dollars a year are now being spent in research, and the complete answer is not yet in sight.

As citizens of this area, we are properly anxious to see industries move into this region. However, it seems inevitable — *unless research works a miracle* — that we must also be willing to accept industrial pollution of some of our streams to a point where they may not be serviceable for anything else.

SEWAGE TREATMENT

What happened to the water from that shower that you, as an Atlantan, were taking today? A few years ago, it would have flowed from this area into Peachtree Creek and through it into the Chattahoochee River. Today, sewage from the northern part of Atlanta flows to Atlanta's largest sewage treatment plant near Peachtree Creek's junction with the Chattahoochee River. This huge plant, which treats 40,000,000 gallons of sewage a day, removes almost half of the organic matter

in the sewage before letting it go into the river. Some of the smaller plants which serve the south part of Atlanta, however, discharge their sewage into smaller streams and have to remove much larger percentages of the organic matter from the sewage.

In the field of sewage treatment, microorganisms are today being extensively used to help remove undesirable matter. It is in this field, however, that many research problems exist, because industrial wastes are so variable and because there are other variations in the nature of sewage.

Why should we even mention sewage or sewage treatment in a discussion of water treatment? Along the course of almost every long river there are, today, many towns and cities, each of which, in turn, uses the water for drinking and other purposes and then discharges it back into the stream. For example, the Ohio River, which forms at Pittsburgh, receives a heavy load of sewage there and continues downstream to be used for water supply and sewage disposal at almost countless places. This is true, to a smaller extent, of the Chattahoochee River, and the problems involved will be of real significance to Atlanta when North Georgia develops its industries further.

This discussion has by no means exhausted the subject of water treatment, nor has it attempted to present full details on even the salient points included. One may safely conclude, however, that those entrusted with the task of water treatment can capably provide us with a safe, clear, soft, and palatable water. In Atlanta, for example, its safety may be controlled by guarding the amount of pollution allowed to flow into the river, and the use of chlorine; its clarity, in spite of the muddiness of the river, may be regained by the use of chemicals and sand filtration; its palatability, at present, is no problem because there is very little upstream pollution; and its softness is due to the nature of the soil in the watershed.

Other localities are not always so fortunate, but it is by no means rash to prophesy that their problems will be lessened by research. Only through research, however — through research on water treatment — can man improve on nature's water and undo the evils concomitant with industrial growth.

DRY BATTERY RESEARCH AT GEORGIA TECH

Continued from Page 8

lower acidity and current density ranges have been well surveyed previously by others, more time has been spent in the Georgia Tech research on experiments conducted at high electrolyte acidity (100 gm./l. of H_2SO_4) and moderate to high current densities (10–40 amp./sq. ft.). The manganous sulfate concentration has been held to 137 gm./l. (50 gm. Mn/l.) in conformity with general practice in other installations of this type. Actually, it has been found that variations in manganous ion concentration of as much as 25 per cent above or below this last figure have little influence upon the operation of the process.

The current efficiency upon plain Acheson graphite anodes is given, in Curve A of Figure 2, as a function of anode current density at a cell temperature of 95° C. It will be seen that there is little hope for an efficient high current density process when conventional graphite anodes are employed. Moreover, there are other serious objections to the use of graphite as the anode material. The consumption of anode graphite (caused by oxidation and mechanical failure) during Georgia Tech laboratory-scale operations has averaged one pound per 8–12 pounds of manganese dioxide produced. Furthermore, the appearance of iron in the product and spent solution has been traced to the presence of some 0.5 per cent of iron in the graphite anodes. Since it is well known that even 30 mg./l. of iron in the electrolyte will completely inhibit the anodic oxidation of manganous

ion, it is highly desirable that an anode free of iron be employed.

Common metals and alloys offer little hope for adaptability as anode materials in this process. However, recent reports describing the use on a large scale of platinum or platinum-clad anodes by certain Western plants producing perchlorates electrolytically have led to a reconsideration of the practicality of platinum anodes in the work of this project. Some of the inherent advantages in the use of platinum anodes are obvious. Platinum is resistant to attack, and a platinum or platinum-clad anode may be expected to last indefinitely without appreciable loss. There is no possibility of introducing iron, carbon, or other harmful impurities into either the product or cell electrolyte. Moreover, other considerations involving the higher oxygen overvoltage at platinum anodes lead to the possibility of obtaining a material increase in current efficiency of manganous ion oxidation over that attainable at graphite anodes.

The current efficiency of manganese dioxide production at a platinum anode, as a function of current density, is plotted in Curve B of Figure 2. The superiority of platinum anodes is quite impressive. Translated into practice, a plant equipped with platinum anodes operating at an optimum current density of 40 amp./sq. ft. would produce daily about four times as much MnO_2 as a plant of equal size equipped with graphite anodes operating at an optimum current density of 10 amp./sq. ft. The savings thus obtained might well be expected to compensate for the high interest charges on the use of platinum. In any case, the goal of an efficient high acid, high current density process appears to be attainable with platinum anodes, but unattainable with the presently available types of graphite anode material.

ELECTRON MICROSCOPE AND X-RAY DIFFRACTION STUDIES

One of the ultimate results of this project, it is hoped, will be a correlation of the structure of electrolytic manganese dioxide with the process conditions employed in production. To this end, all MnO_2 samples produced have been subjected to X-ray and electron microscope examination; typical electron micrographs and X-ray diffraction patterns were reproduced in the previous paper in this series.[1] To date, all samples produced at high electrolyte temperature, i.e., above 80° C., have the structure characteristic of battery-active gamma MnO_2. There are some small variations in structure in the products produced at platinum anodes, but their meaning is not yet clear.

BATTERY SERVICE TESTS

A considerable number of test dry cells employing Georgia Tech electrolytic MnO_2 as depolarizer have been fabricated at the Squier Signal Laboratory, Fort Monmouth, New Jersey. All of these MnO_2 samples have given performance in the Signal Corps BA–2 test approximately equal to, and in most cases quite superior to, African Gold Coast ore. As mentioned, the latter is the best naturally occurring battery depolarizer, and its average initial performance in the BA–2 test is stated by the Squier Laboratory to be 90 hours. The best Georgia Tech sample has given 127 hours initial service; the poorest, 91 hours. The average

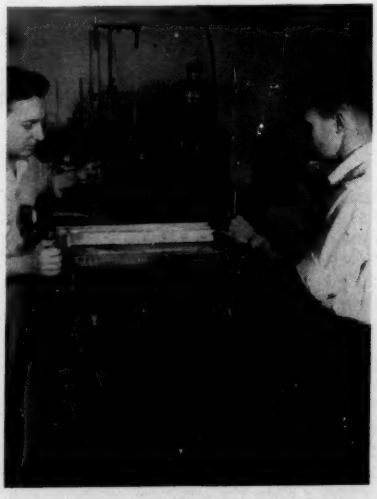

Figure 3. Semi-pilot plant for the electrolytic synthesis of battery-active manganese dioxide.

of initial service life tests for all Georgia Tech samples thus far tested is 107 hours. Dry cell service life in the BA–2 test after three months storage at 70° F. has also been measured for many Georgia Tech samples, and averages 93 hours, representing a drop in average capacity of 13 per cent. For more than half of the samples the drop was less than 10 per cent. These data, while limited in extent, are encouraging. Heretofore, the most serious shortcoming of dry cells prepared with synthetic manganese dioxides has been the extreme drop in battery capacity after even brief storage periods.

PLANS FOR FUTURE WORK

The laboratory work on the development of the process is now essentially complete, and operations are under way on a semi-pilot plant scale. Platinum and graphitic anodes are being employed. The electrolytic cell employed in this semi-pilot plant is shown in Figure 3.

Weekly production from this semi-pilot plant varies from 10 to 25 pounds, depending upon process conditions. The large quantity of MnO_2 made available by the semi-pilot plant will permit distribution to dry cell manufacturers for testing under their own conditions, and will assist in further developments in the production process and structural studies of battery-active MnO_2.

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AERONAUTICAL ENGINEERING GRADUATE THESES

Continued from Page 10

Gus Richmond, Jr., ***Strain Measurements in Thin Shear Web Aircraft Type Beams.*** Faculty advisor: Professor G. K. Williams.

Although the latest theory published by the National Advisory Committee of Aeronautics for calculating primary stresses in buckled webs is supported by a considerable amount of experimental data and gives excellent results in the elastic range, it provides no method of evaluation of the secondary stresses caused by the formation of buckles. The purpose of this study, therefore, was the more precise determination of the quantitative values of strains present in buckled webs of different a/b ratios and the presentation of the corresponding stresses.

Two types of 24-ST aluminum alloy panels, *viz.*, pure shear and transverse shear beam panels, were tested by using electrical strain gages to determine the type and magnitude of the stresses present. Both primary and secondary strains were measured at positions considered to be critical.

From the strains measured in these tests, the stresses present were calculated, taking into account the effect of Poisson's ratio.

Curves were plotted of these stresses for each panel tested, and two families of curves were drawn to show the variation of outer fiber stresses with a/b ratio. Finally, the theoretical primary stresses were calculated by the latest theory on incompletely developed tension field beams, and these stresses were plotted along with experimental data as a family of curves, for comparison.

The tests made indicated that strain measurements can be made of secondary stresses as well as primary stresses, and results with only slight scatter of points can be obtained, provided care is used in locating the strain gages. *E. P. C.*

Alfred Ritter, ***A Study of the Double Venturi Principle in Its Application to High-Speed Wind Tunnels.*** Faculty advisor: Professor Alan Pope.

A double venturi consists of an arrangement of two venturi tubes, one larger than the other, such that the discharge of the smaller or primary venturi will exit into the throat of the larger or secondary venturi. By placing this double venturi into a stream of air, it is possible to obtain

extremely low pressures in the throat of the primary venturi, much lower in fact than would have occurred if only the primary venturi was placed in the air stream. Since it is known from Bernoulli's theorem that pressure decreases are accompanied by velocity increases, this double venturi principle gives rise to the possibility that it may prove useful as a source of high-velocity air for wind tunnel testing.

A number of variations of double venturis were tested in a six-inch-diameter duct in order to determine the maximum velocity increase in the forward (primary) venturi, and the power required, with an aim toward using the double venturi to achieve a small area, high-velocity region from a large area, low-velocity region. It was found that the double venturi could be used to obtain velocity increases of the order of four and a half times that obtained in a low-speed test section. It was also observed that the horsepower required would probably not be excessive. Further studies are to be made in the future. *M. B.*

James Parker Sturrock, *An Investigation of the Characteristics of a Supersonic Wind Tunnel Diffuser.* Faculty advisor: Professor Alan Pope.

The diffusion of supersonic flow back to atmospheric conditions necessarily requires deceleration through the speed of sound. Although it is theoretically possible to do this without the formation of shock waves, this is not possible in practice due to pressure fluctuations that tend to develop such waves. A survey of the literature indicated the desirability of developing a shock of low intensity, in which case it would have to occur at the minimum section between the supersonic and subsonic sections of the diffuser. This survey also indicated that the stability of the shock wave could possibly be increased by lengthening the minimum section of the diffuser. One purpose of this investigation was, therefore, to try to determine experimentally the effect of various ratios of minimum section length to diameter (L/D) upon shock wave stability.

A small supersonic wind tunnel was designed and constructed for the purpose of testing diffuser characteristics. The test program included investigations of boundary layer effective thickness, diffuser efficiency, normal shock wave stability in the diffuser throat, and pressure regulation characteristics.

The data obtained were analyzed, and, as a result, it was found that the boundary layer thickness at any given point was approximately three times as great as previously reported. *E. P. C.*

SERIES NUMBERING OF THE RESEARCH ENGINEER

When the first issue of THE RESEARCH ENGINEER was issued in May, 1946, it was placed in the Engineering Experiment Station's "Circular Series" for two reasons: (1) this series, by definition, is intended to contain those Station publications "which present important information that is not otherwise readily accessible to the public and to the engineering profession," and (2) it was then deemed unwise to add a new "series" category to the several already issued by the Station—Circulars, Bulletins, Reprints, and (more recently) Special Reports.

Except for Special Reports, all the above series categories form part of an over-all Station Publication Series. Each new publication—Circular, Bulletin, or Reprint—is given the appropriate volume number of this series (that for 1948 is Vol. X) and whatever issue number that follows the immediately preceding publication. Thus, the May, 1946, issue of THE RESEARCH ENGINEER was published as "Circular 5 in the Station's Publication Series, Vol. VIII, No. 7"; the September, 1946, issue happened to be Circular 6, Vol. VIII, No. 10, etc.

Concurrent with the decision, this summer, to apply for postal entry of this journal as second-class matter came the decision to remove THE RESEARCH ENGINEER from the numbering pattern of the Station Publication Series and to give it a series designation of its own. The scheme adopted is simple: this journal is issued five times yearly—in May, September, November, January, and March—so each year's issues will bear the appropriate yearly volume number (1948-1949 Volume, at present) and the correct issue number, beginning with the May issue as Number 1. Accordingly, this issue is Number 3 of the 1948-1949 Volume.